



STATE & PRIVATE FORESTRY FOREST HEALTH PROTECTION SOUTH SIERRA SHARED SERVICE AREA



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From: Forest Health Protection, South Sierra Shared Service Area

Subject: Biological Evaluation of Bark Beetle Activity in the Soaproot project, Big Creek Watershed

Introduction

Bark beetle activity in the Big Creek watershed, High Sierra Ranger District, Sierra National Forest has been mounting since 2006, chiefly within established ponderosa pine plantations and predominantly mature pine stands. Bark beetle-associated mortality is highly visible in the watershed, appearing to have intensified within the past two years (Figure 1).

In response to increasing activity, district silviculturist Ramiro Rojas requested a biological evaluation of current and potential bark beetle conditions within the boundaries of the Soaproot project, as well as assessing activity in mature plantations located across Big Creek around Nutmeg Saddle. Forest Health Protection entomologist, Beverly M. Bulaon assisted by Kathryn Kiehl evaluated several locations this summer. Ground surveys of uninfested, currently infested, recently burned, and winter snow damage areas of the project and additional plantations were assessed. This report summarizes ground and aerial observations, and presents management options regarding western pine beetle.



Figure 1. 2009 & 2010 Western pine beetle-associated mortality noted in the High Sierra Ranger District.

Background

The Soaproot project, located in the Southwest corner of the High Sierra Ranger District and the Northern portion of the Big Creek Watershed (Figure 2), spans elevations from 3000 to 7000 feet and receives 50 – 60 inches of precipitation annually. Proposed areas for treatment are a combination of ponderosa pine plantations and natural stands. Many of the pine plantations are approximately 60 years old and were initiated after the 1947 Bretz fire. Natural stands within the Soaproot project are primarily mixed conifer-pine type with high frequencies of large diameter ponderosa and sugar pines. Incense cedar, white fir, and black oaks comprise half of the overstory, and greater than half of the regeneration composition. Main treatments in Soaproot project are thinning and fuel reduction.

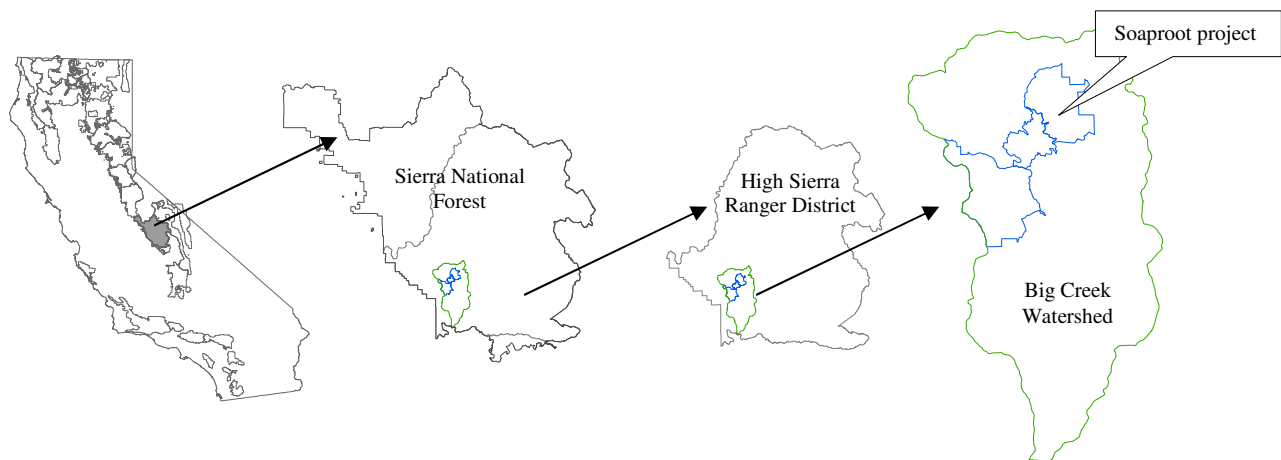


Figure 2. Soaproot project area spatial reference within the Big Creek Watershed on the High Sierra Ranger District, Sierra National Forest.

Additional plantations (otherwise known as the Nutmeg Plantations) that were assessed were located south of Dinkey Mountain, primarily within Nutmeg Saddle (Township 11 S, Range 26 E, Sections 5-8, 17, 18). Most areas are east-faces, around 4000 feet in elevation. These pure ponderosa pine plantations were also established after the Hazlet Basin Fire 1961. Thinning treatments on gentle slopes have been implemented. These treatments removed less than 10% of basal area. In the remaining steeper slopes (majority of area) no treatment has been implemented in over 30 years on these sites. Density and fuel reduction are proposed treatments.

Bark beetle related mortality has been increasing throughout the southern Sierras for several years. Possible contributors of this increase in beetle activity include successive drought years, overstocking, root disease, and recent winter storm damage. Mortality in ponderosa pines have been especially high within and around the Soaproot project, as evidenced from ground and aerial surveys taken over the past five years (Figure 3).

Aerial Survey Information

Aerial mortality surveys are conducted annually by Forest Health Monitoring, USDA Forest Service. These annual aerial surveys are invaluable in providing landscape overviews and trends of pest caused mortality over time. Although aerial surveys are conducted in variable conditions (i.e. cloudy, hazy, etc.) and simply provide snapshots of stands at a specific time within the year, they provide general location information and help track patterns of recent bark beetle activity and/or expansion on the landscape.

Surveys conducted since 2005 show fluctuations in bark beetle activity around the Big Creek watershed (Table 1). On a project scale, Soaproot project area had continual increase in bark beetle activity from 2006 – 2010 (with the most significant increase between 2009 and 2010) (Figure 3, Table 1). Much of the mortality was determined to be associated with western pine beetle (*Dendroctonus brevicomis*, WPB) in ponderosa pine. Total estimated acres affected ranged from 243 to 1349 in the Big Creek watershed and from 42 to 419 within the Soaproot project area from 2005 to 2010 (2010 had the largest affected acreage). The estimated number of trees killed per acre also increased from small group (1-3 trees) to massive group attacks (60+) during 2009 to

2010. The accumulated and intensifying mortality within the watershed indicates building populations of beetles that would suggest higher losses during the 2011 flight season.

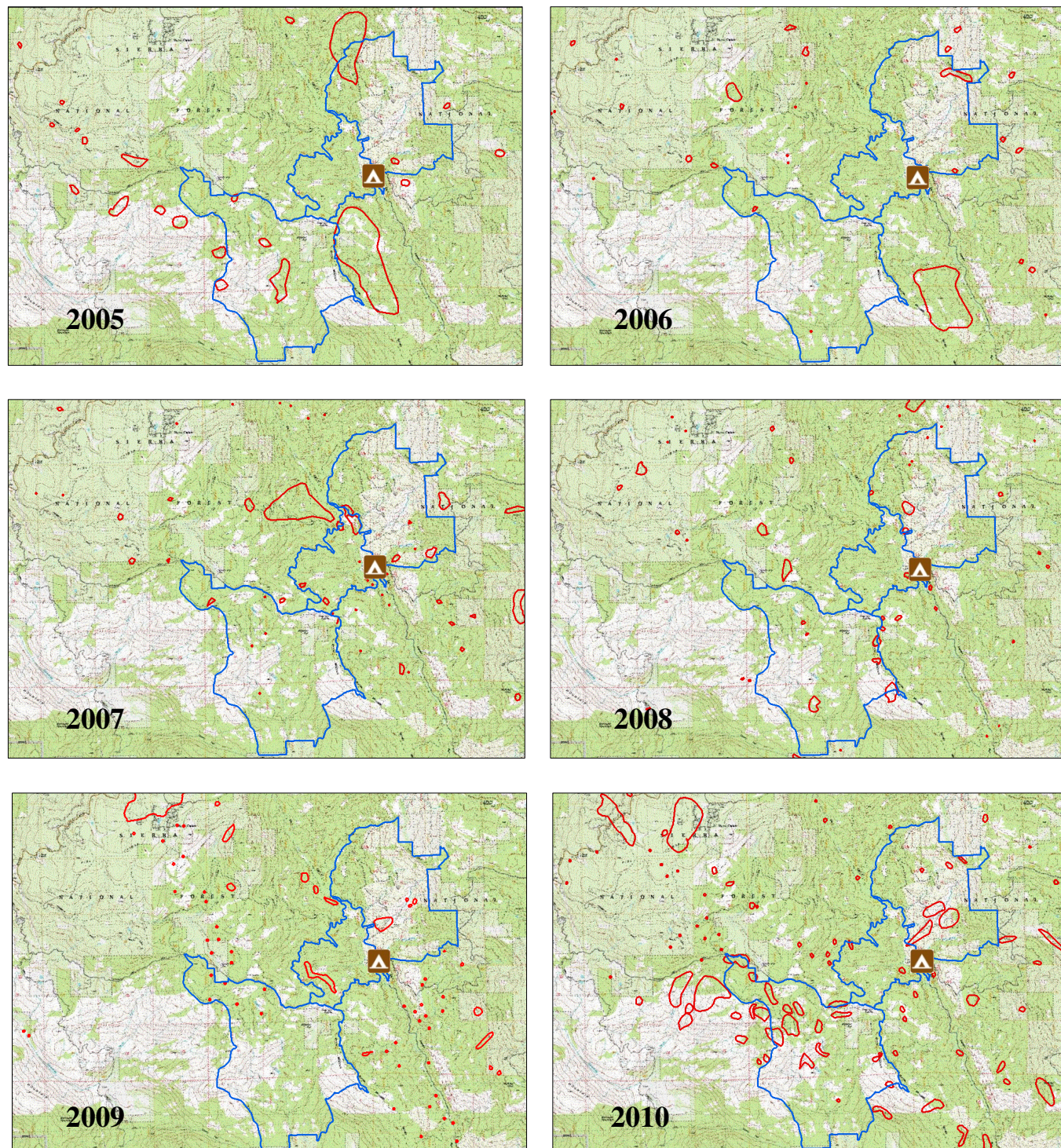


Figure 3. 2005-2010 Aerial Surveys of the Big Creek Watershed, High Sierra Ranger District. Soaproot project area (blue outline) and Bretz Mill campground are shown on the map.

Table 1. *Estimated total acres of mortality from 2005 – 2010 in the Big Creek watershed and Soaproot project areas.*

Year	Big Creek Watershed	Soaproot Project Area
2005	1348	226
2006	633	42
2007	555	86
2008	243	91
2009	277	89
2010	1349	419

Observations

Stand conditions were evaluated from FHP ground surveys and district stand exams as they relate to susceptibility for infestation and potential loss. Regional risk ratings created for western pine beetle are based on studies that examine several environmental and host variables such as stand density, stem sizes, and stocking.

Ground surveys coupled with aerial detection information confirmed that a large percentage of loss in the watershed was western pine beetle-infested ponderosa pine. Surveys were focused where activity appeared most severe, particularly along the Peterson Mill Road and Nutmeg Saddle. Fir engraver (*Scolytus ventralis*) activity in white fir and sugar pines attacked by mountain pine beetle (*Dendroctonus ponderosae*) were also noted, but overshadowed by WPB-associated mortality. Western pine beetle galleries were observed in all survey and bark beetle mortality plots. Highest losses were noted in densely-stocked mature plantations where average diameter of planted pines was 15 inches and above.



Figure 3. *Typical group kill of ponderosa pine caused by Western Pine Beetle.*

Mortality caused by western pine beetle in natural stands primarily occurred in moderate to large diameter pines (> 19 inches on average) (Figure 4). Mortality groups ranged in size from singular attacks that moved systematically within a stand over the years selecting just weakened trees, to larger pockets of 5-10 trees all killed within the same year. For these groups, it was estimated that most of these occurred during 2009 and 2010. WPB typically seeks only weakened trees, which signify its scattered pattern of mortality under endemic conditions. Attacks may expand to group kills as more trees become susceptible when entire stands experience stress from drought, fire, pathogens, or other factors. Other bark beetles such as red turpentine beetle (*Dendroctonus valens*, RTB) and pine engravers (*Ips* spp.) were observed on damaged trees. Numerous red turpentine beetle pitch tubes, new (2011) and old (2010) attacks were noted on approximately half of the trees attacked by WPB or with terminal kill by pine engraver species. No trees were found with only with RTB attacks.

As for plantations, Nutmeg Saddle on the east side of Big Creek was recorded with the highest counts of attacked trees per year and per acre. Within a 1/20th acre plot, 10 of 18 ponderosa pines were successfully attacked; 23 total-killed within a one acre group. Nutmeg plantations greater than 40 years old, where average diameter exceeds 13 inches and SDI is typically > 400, experienced the highest losses per acre (>20 trees/acre) within the project area. However, a younger heavily stocked plantation located along Barnes Mountain (road 10S05), with average pine diameter of 10 inches was estimated to contain over 100 (2009 killed) trees within one site.

Severe winter storms (strong winds and heavy snow loads) in the winters of 2009-2010 and 2010-2011, caused many green trees to snap mid-bole, drop large green limbs, and terminals to fracture. Green debris on the ground and standing snags are prime habitat for bark beetles; and consequently, all debris greater than 2 inches in diameter had pine engravers and/or WPB infestations. Large brood populations had successfully developed in slash, then moved into standing green trees. One pocket of sapling-sized pines, with thick snow breakage debris, had over 40 trees killed (Figure 4). Trees snapped in 2009 and infested by WPB, spawn brood that continued to attack neighboring trees the following years. The heaviest storm damage occurred in dense pockets of small trees, which are more susceptible to breakage than open stands (Oliver 1995). Over 20 trees (greater than 5 inches) were sheared off mid-bole by high winds in one stand alone (Figure 5).



Figure 4. *Snow damage debris and live pines infested by pine engravers.*

Figure 5. *High density stand along Road 10S0, tops sheared off by wind/snow possibly early 2010. Debris was currently infested by pine engravers.*



Minimal bark beetle activity was noted in recently prescribed burn areas such as those around the Peterson Mill site along the north end of Rush Creek. Direct effects from fire seemed only to be correlated when bole scorch was estimated at 40% or greater; small diameter trees (<6 inches) with severe scorch were dead in plot surveys, but without insect damage. On average, bole scorch within the prescribed burn was assessed at 20% or lower. Most beetle-kills within the Virginia Prescribed Burn were associated with previously infested neighboring trees, or storm debris that most likely attracted beetles into the area (see Figure 6).



Figure 6. *Ponderosa pines in Virginia burn successfully killed by western pine beetle. NOTE: broken stems and tops of surrounding trees; damage from storms and not from prescribed fire most likely contributed to continued bark beetle activity within this stand.*

Discussion and Summary

Mortality within the Big Creek watershed has been a consequence of prolonged drought events in California coupled with stand conditions that are highly conducive to bark beetle attack. Severe droughts are especially stressful to trees, and bark beetles are quick to respond to weakened hosts. In California, drought significantly influences attack susceptibility by causing additional stress. Healthy trees produce copious amounts of resin that function as physical and chemical barriers to prevent beetles to become established. Moisture stressed trees are unable to produce sufficient resin to resist attacks. Kolb et al. (1998) found that water potential in foliage of ponderosa pine increased when formerly dense stands were thinned, showing improvements in phloem thickness and resin flow. Heavy stocking is an additional factor that compounds water stress and leads to increases in resource competition between trees. Recent above-average precipitation in the Sierras may lessen attack risk by reducing overall tree stress, but attacks will resume if stand density is not altered before the next drought cycle occurs. Long-term prevention measures are strongly recommended to reduce further losses of ponderosa pine, especially in overstocked, high density stands. Treatments, such as thinning, may provide stress relief needed to promote stands of healthy trees, capable of resisting and/or surviving beetle attack. Depending on project objectives, treatments can be modified to meet additional goals or provide other benefits such as fuel reductions or wildlife habitat.

Oliver (1995) was the first to suggest that susceptibility of pine stands to WPB attack could be estimated by stand density, particularly measured by stand density index (SDI) which measures available growing area for the stand. Risk for imminent mortality and the percentage of loss could be estimated when densities surpassed

particular thresholds. SDI's > 230 are the most at risk for losses caused by endemic bark beetles, and large losses can be expected as SDI approaches 365 (Oliver 1995). More simply put, as SDI increases, attack risk increases. Hayes et al. (2009) also suggest SDI's below 230, stating, mortality will occur as low as 170 SDI during times of high beetle activity. Therefore, priority areas for treatment should be those with the highest stand densities, as those are expected to experience greatest loss (Hayes et al. 2009).

The 2009 Virginia prescription burn was successful in reducing stocking and release, and although beetles were found, activity was low and attributed to factors unrelated to fire – most likely storm damage or high neighboring beetle populations. Not surprising, given that infestations developing into large group kills within or progressing outside of fire boundaries have never been recorded in California. Observations of bark beetle attacks in green areas surrounding a burn more often result from poor stand conditions rather than a burn area-supported beetle population.

Healthy forest ecosystems contain healthy balances of insects and diseases to create disturbances that promote change. Insects mentioned here are native, having co-evolved with hosts over centuries and act as natural mortality agents. Mortality or damage caused by insects is beneficial to wildlife and resource recycling. For example, bark beetles are a favored food source for woodpeckers and dead trees fall and create gap openings for new trees to develop. Snags or “imperfect” trees can be essential nesting habitats for wildlife and as trees rot, nutrients are returned to the soil and biomass is recycled into the system. While the current level of mortality may be above acceptable project levels, benefits for other forest resources may be attained.

No- treatment options within the project area will have effects that may lead to more losses of pine. Based on Oliver's susceptibility indexes, mature plantations remain at high risk against bark beetle infestation. Large expanses of forest mortality may be experienced, creating an immense future fuel load. White fir, a more shade tolerant species, will continue to increase in abundance, potentially outcompeting the pines in the stands. Such imbalances in species diversity in mixed conifer stands lead to higher incidences of root disease and dwarf mistletoe (Bulaon et al., 2008). The combination of high stand densities, large average diameters in host pines, and drought conditions have been conducive to providing optimal bark beetle habitat and subsequently, population buildup. With documented changes in future climate conditions and higher potential for catastrophic fires in western forests, treatments that focus on ecological restoration and resistance improve chances for resiliency against major disturbance events.

Recent 2010-2011 precipitation levels have set new records for the state, but tree resistance against attacks may be temporary lasting only until the next drought cycle occurs, unless stand conditions are altered that improve individual tree vigor and resilience. Bark beetle prevention treatments are encouraged when water resources are plentiful as trees can acclimate, recover, and build resistance rapidly. Treatments to enhance tree resistance mechanisms reduce overall susceptibility to attack as well as improve resiliency when water becomes limited. Management strategies that reduce resource competition, such as silvicultural thinning, are effective prevention measures that will provide other benefits such as fuel reduction and resource redistribution.

If you have any further questions or require more information, please do not hesitate to contact us.

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Appendix A. Western Pine Beetle (WPB) Biology and Background

Western pine beetle is a native bark beetle of western forests. Ponderosa pines greater than 6 inches are its principal host, but have been known to also attack Coulter (*Pinus coulteri*). Successfully mass-attacked trees are usually predisposed by various root diseases, dwarf mistletoe, fire, mechanical injury, or overstocking. Prior infestation by Red Turpentine Beetle (*Dendroctonus valens*) at the base or pine engravers (*Ips* species) in the terminal increase risk for subsequent attack. In California, mortality associated with western pine beetle is closely correlated with prolonged drought events.

Depending upon elevation and recent spring temperatures, western pine beetles have one to multiple generations in the southern Sierra Nevada. Overwintering beetles emerge in the spring as soon as temperatures warm up and will continue flying into fall months. Evidence of attack are either small “pitch tubes” found in the crevices of the bole where beetles have entered. Numerous red (mixture of resin and boring dust) pitch tubes usually indicate successful attacks. Tree can survive if there are only white-colored tubes (typically unsuccessful attack) or tubes along one side (strip attack). Tree decline is further accelerated by infection of blue stain fungi vectored by beetles boring into the phloem.

Group kills of WPB reflect conditions of the stand and individual tree health. Dense or overstocked stands are at highest risk for infestation. Trees become stressed by increased levels of growing space or resource competition, especially during times of low annual precipitation. Pathogens or other injury compound trees physiological stress, increasing attraction to beetles. Mature even-aged pine plantations are considered at highly susceptible to attack due to host availability, preferred size classes, and frequent dense stand conditions.